Observation of the two hole satellite in Cr and Fe metal by resonant photoemission at the 2p absorption energy

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INTRODUCTION

High energy spectroscopies represent established methods for studying the electronic structure of atoms, molecules and solids. With the advent of high-flux synchrotron radiation sources, resonance experiments such as resonance photoemission, resonance x-ray scattering, or resonance Auger spectroscopy have become interesting new tools[1,2,3]. RPE consists of performing a photoemission experiment on one electronic level with a photon energy equal to the absorption energy of another deeper core level of one of the constituents. We report the first successful attempt to observe the two hole valence band satellite in Cr and Fe metal. In addition an unexpected cross-over from the RRAS regime to the Auger regime in these two systems is reported.

EXPERIMENT

The experiments were performed at beamlines 7.0.1 and 9.3.2 of the Advanced Light Source. The resolution in the photon channel varied between 100 meV and 230 meV, and in the electron channel between 100 meV and 250 meV. The width of the $2p_{3/2} \rightarrow 3d$ absorption line was ~ 2.5 eV (measured as FWHM) and therefore, as required for straightforward analysis of the data in term of RRAS,[4] the width of the incoming photons was small compared to that of the resonance. The samples were thin films (80 angsrom to 200 angstrom) of pure Cr or Fe evaporated onto W(110) substrates. The quality of the sample was verified by their LEED spectra and a barely visible O 1s signal.

RESULTS AND CONCLUSION

It has been demonstrated, that the equivalent of the 6 eV valence satellite in Ni can be seen by the RRAS technique in Cr and Fe metal at 3.5 eV and 3.2 eV below E_F, respectively. However, while in Ni this state is accessible by the PES and Auger channel in Cr and Fe it can only be reached via the Auger channel. In all three cases, the RRAS behavior switches to an ordinary Auger behavior if the photon energy reaches approximately the binding energy. The present data, taken together with those of Ni[5], thus demonstrate how, with the help of a high-intensity third-generation synchrotron radiation source resonance techniques that were previously limited in their applicability due to low count rates, can be brought to use, thus revealing additional aspects of the electronic structure of solids.

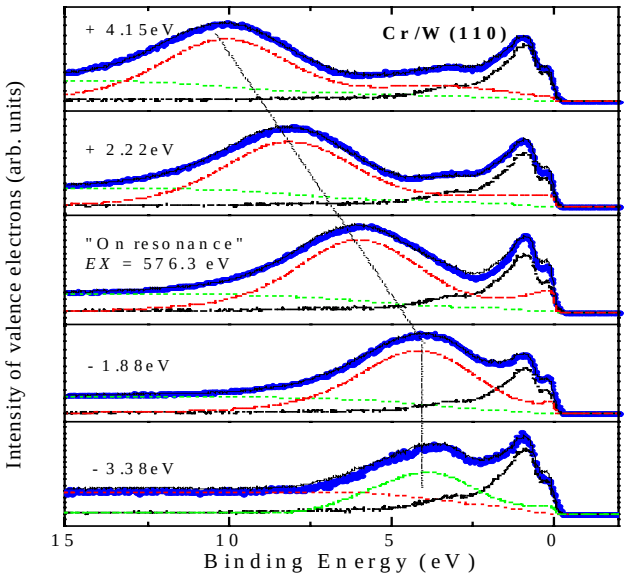

Fig.1 Extracted valenace band spectra of Cr around the $2p_{3/2}$ energy (576.3 eV) in order to show the shift of the Auger energy with photon energy (and the absence of it) below the $2p_{3/2}$ absorption energy. The underlying dashed curves and points represent a simulation of the spectra using the Auger spectrum, the background, and the valence spectrum derived from measurements at a photon energy where they are well separated from each other.

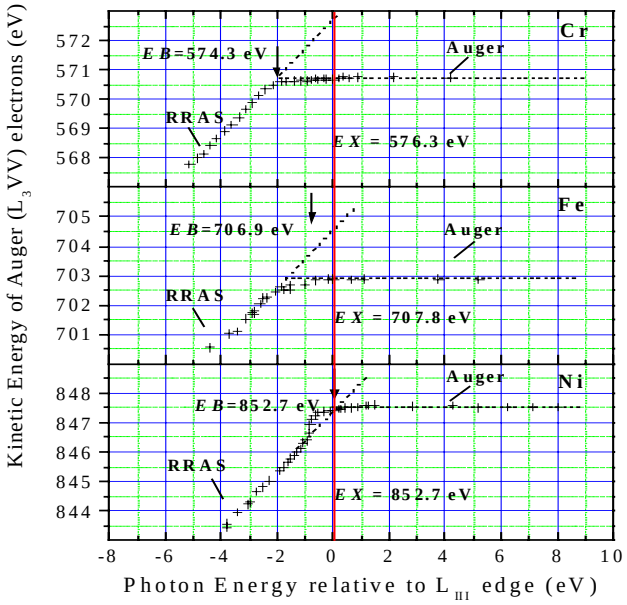

Figure 2. Plot of the peak of the *L_3VV* Auger kinetic energy for Cr, Fe [this work] and Ni [ref. 6] relative to its energy at the $2p_{3/2}$ maximum absorption energy, as a function of the difference in photon energy from that of the $2p_{3/2}$ absorption maximum.

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